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Robustness to set-up errors for treatment plans for superficial tumors in head and neck radiotherapy

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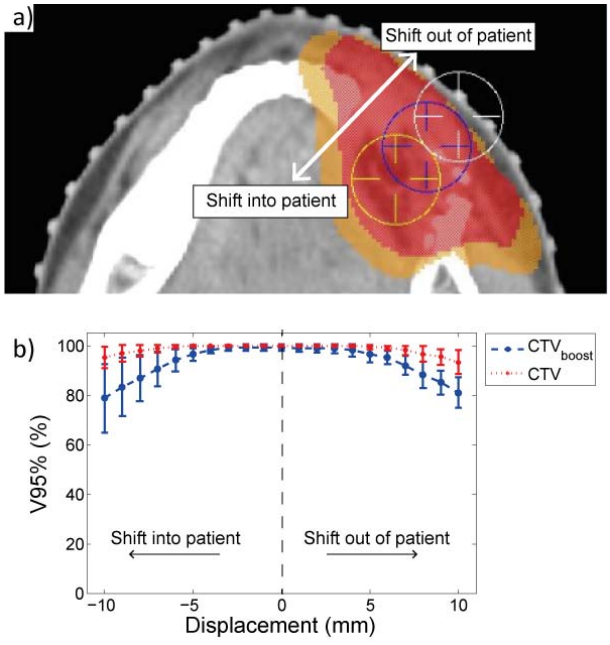
Purpose or Objective: Clinical target volumes (CTV) in the head and neck region are typically located just beneath the skin. Therefore, planning target volumes (PTV) will be outside the body contour. Moreover, for IMRT and VMAT treatment plans the build-up region is excluded from the PTV in the treatment planning system and optimization is done on the remaining part of the PTV (in our institute excluding the PTV outside the patient and a margin of 4 mm beneath the skin). This study evaluates the robustness of such treatment plans to set-up errors.

Material and Methods: Seven head-and-neck treatment plans were evaluated (VMAT, SIB with 54.25 Gy to the CTV and 70 Gy to the CTVboost in 35 fractions, CTV to PTV margins were 3 mm, Pinnacle Treatment Planning system). To investigate the effect of set-up errors on CTV coverage, a patient-shift on the treatment table is simulated as a shift of the isocenter. The isocenters were shifted in steps of 1 mm up to 10 mm for each of these treatment plans, in both directions ("into the patient" and "out of the patient", see Figure 1a; direction chosen in such a way that shifts out of the patients have the most effect). Subsequently, it was evaluated up till which step in mm the DVHs of the simulated (shifted) treatment plans were clinically acceptable (V95% > 99%).

Results: The effects of the shifts on the V95% of both the CTVboost and the CTV can be seen in Figure 1b. For the CTVboost regions (indicated by the blue line), it was found that the V95% was still 99% up to a shift of 3 mm (irrespective of the direction, into or out of the patient). For the elective region the V95% is still high enough (above 99%) up to a shift of 6-7 mm (6 mm into the patient, 7 mm out of the patient).

Figure 1 a) Effect of set-up error is simulated by shifting the original isocenter used for the delivered treatment plan (indicated by blue crosshairs) in the direction out of or into the patient (as indicated by the white arrow). The displacement of 10 mm into the patient is indicated by the yellow crosshairs, 10 mm in the direction out of the patient by the white crosshairs. CTVboost and CTV are indicated by red and orange colorwash respectively. b) The V95% values of the CTVboost and CTV due to the shifts of the isocenter.



Conclusion: This work shows that treatment planning in the head and neck region with a CTV to PTV margin of 3 mm and subsequent subtraction of a build-up region of 4 mm results in adequate CTV coverage up till setup errors of 3 mm. Since in clinical practice setup errors are well below 3 mm, this is a safe strategy.

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VMAT FFF irradiation in deep inspiration breath hold

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Purpose or Objective : Radiotherapy treatment on a lung moving tumor requires much caution. Among various treatments possibilities, the patient can be irradiated in deep inspiration breath hold during VMAT delivery. The purpose of this study was to investigate the feasibility of such irradiation. First, dosimetric effects of beam interruptions on VMAT delivery were determined. Then we studied the way to optimize dosimetry with multiple sub-arcs permitting breath hold. Finally another way to irradiate has been adjusted for a faster treatment while keeping VMAT advantages. We need to use a flattening filer free beam (FFF) to keep the irradiation time as low as possible.

Material and Methods: Dosimetric effect of beam interruptions delivery was studied depending on modulation, beam off numbers, dose rate and accelerator (TrueBeam, Clinac 2100C/S). We compared: absolute and relative dose and MLC Dyna/Trajectory Log files. Two rotations of 194° (clockwise/counterclockwise) were divided until 6 segments. Theirs overlapping or spacing have been compared (Eclipse). Dosimetric FFF plans with sub-arcs method was studied for 2 rotations of 360° depending energy, dose rate, segments numbers and treatment time.

Results: The maximal dose variation with beam interruptions was equal to 0.23%. TrueBeam Logfile showed that 10% of the control points have a difference higher than 0.05 mm between real and planning positions versus 70% with Clinac. The PTV volume receiving 95% of the prescribed dose V95% was equal to 99,35% with two arcs of 194° and 92,35% with one arc. When irradiation was performed with 6 segments spacing of 20°, V95% reach 98,08% with a dose reduction for the organs at risk (spinals cords: 2,2 Gy against 2,6 Gy). The sub-arcs method provided 6 arcs of 12 seconds compared to the standard 2 arcs of 40 seconds. Using FFF beams, the planning dosimetry was close to the standard treatment (Volume factor of injury cover equal 0.96 against 0.95) with a better OAR protection (spinals cords: Dmax=18,51 Gy with X6FF/2arcs, 11,75% with X10-FFF/6 arcs). For one rotation of 360°, the standard treatment needs 131 seconds versus three arcs of 12 seconds with FFF and sub-arcs.

Conclusion: We observed no significant dosimetric effect caused by beam interruptions. In order to have a shorter and a safer irradiation, the gantry rotation can be divided in several segments of 20° spacing. The dose distribution difference is insignificant and the OAR are better protected. The use of FFF and segmentation allows reducing the irradiation time by six.

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Feasibility of an "off-target isocenter" technique for cranial intensity-modulated radiosurgery

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Purpose or Objective: To evaluate the dosimetric effect of placing the isocenter away from the planning target volume on intensity-modulated radiosurgery (IMRS) plans to treat brain lesions.

Material and Methods: Fifteen patients, who received cranial IMRS at our institution, were randomly selected. Each patient

was treated with an IMRS plan designed with the isocenter located at the target center (plan A). A second off-target isocenter plan (plan B) was generated for each case. In all plans the 100% of the prescription dose covered the 99% of the target volume. The plans A and B were compared for the target dosage (conformity and homogeneity indices) and organs at risk (OAR) dose sparing. Peripheral dose falloff was compared by using the metrics V12 (volume of normal brain receiving more than 12 Gy) and CI 50% (conformity index at the level of the 50% of the prescription dose).

Results: The values found for each metric (plan B vs. plan A) were (mean ± SD): CI (1.28 ± 0.15 vs. 1.28 ± 0.15, p = 0.978), HI (1.29 ± 0.14 vs. 1.34 ± 0.17, p = 0.079), maximum dose to brainstem (2.95 ± 2.11 vs. 2.89 ± 1.88 Gy, p = 0.813); maximum dose to optical pathway (2.65 ± 4.18 vs. 2.44 ± 4.03 Gy, p = 0.195) and maximum dose to eye lens (0.33 ± 0.73 vs. 0.33 ± 0.53 Gy, p = 0.970). The values of the peripheral dose falloff were (plan B vs. plan A): V12 (5.98 ± 4.95 vs. 6.06 ± 4.92 cm3, p = 0.622), and CI 50% (6.08 ± 2.77 vs. 6.28 ± 3.01, p = 0.119).

Conclusion: The off-target isocenter solution resulted in dosimetrically comparable plans as the center-target isocenter technique, by avoiding the risk of gantry-couch collision during the CBCT acquisition.

EP-1657

DVH analysis automation in Tomotherapy

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Purpose or Objective: The extraction of the data from DVH, with the aim of perform an analysis of a large number of patients in a research project, is a time-consuming process. Furthermore, in the case of Tomotherapy, the resolution obtained from the DVH is poor. This lack of resolution may suppose an additional source of error of this analysis. With the aim of solving these problems, we have developed an easy macro using the Microsoft Excel®, which allows performing the analysis of as many patients as you wish with a single click, improving the resolution and allowing the analysis of up to 7 structures in each histogram.

Material and Methods: a. Input data: 1. The dose range displayed on the DVH has to be the same in all patients. 2. Up to 7 structures can be chosen in each patient, and the same structure has to be identified with the same color in all the analyzed patients. The seven colors that can be chosen are red, green, blue, cyan, yellow, magenta and black. 3. Thereafter, a screenshot of the DVH has to be saved. b. Programming: Macro in ImageJ: 1. Open the DVH in RGB format image. 2. Split images on the RGB channels. 3. One image is obtained for each structure once the image subtraction has been performed, obtaining one single histogram for each structure. 4. The line tool will allow obtain either the dose reached in a given volume or the volume enclosed in an isodose. 5. The macro generates a plot profile and a list of values, which are saved in an independent .xls archive. Macro in Excel: 1. Opens the .xls files generated by the ImageJ macro. 2. Opens the .xls files. 3. Finds the maximum of every list. 4. Calculates the value of the histogram corresponding to this maximum. 5. Store this value in an .xls archive where all the data analyzed are stored.

Results: I.e., in a case of prostate cancer with seven structures under study, a total of 16 items are analyzed: PTV prostate and PTV nodes: 98% and 2% of volume. Rectum: V50, V60, V65, V70 and V75. Bladder: V65, V70, V75 and V80. Femoral head (left and right): V50 Penile bulb: V90 a. Time per patient: Manual: 10 min Macro: 30 s (time necessary for the preparation of the histogram). b. Resolution: Manual: X axis (dose): 16,95 points per Gy. Y axis (% volume): 0,37 points per 1% of volume. Macro: X axis (dose): 14,84 points per Gy. Y axis (% volume): 3,78 points per 1% of volume.

Conclusion: This new macro is a powerful and user-friendly tool designed to help the investigators to perform a quicker data analysis, allowing to perform it up to ten times faster. This is especially useful in the case of analyzing structures with multiple control points, as is the case of rectum and bladder. Likewise, the results obtained with the macro provide a better resolution than measured data, specially, in the y-axis, where the resolution may be improved about ten times. These kind of macros may be programmed to obtain data from as many patients and as many values as desired in the seven structures of the DVH.

EP-1658

Comparing of two different techniques for WBRT with SIB for patients with single brain metastasis

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Purpose or Objective: The aim of this study was to evaluate and compare the non-coplanar IMRT and coplanar VMAT techniques for the treatment of patients with single brain metastasis and their influence on the absorbed dose by the OARs.

Material and Methods: Treatment planning computed tomography (CT) scans of 6 patients with single brain metastasis who had received palliative whole brain radiotherapy (WBRT) with simultaneous integrated boost (SIB) was recruited. Each patient re-planned with 9 fields non-coplanar IMRT and coplanar VMAT for dosimetric comparison. Details of the field arrangement in IMRT plan are presented in Table 1. Two coplanar full arcs by Varian Millennium 120 MLCs were used in all VMAT plans. Arcs were arranged with 30 degrees collimator to protect MLC leak. Prescribed WBRT dose was 30 Gy in 10 fractions and SIB dose was 39 Gy in 10 fractions. Radiation doses to OARs and targets, conformity and homogeneity index and monitor units from two techniques were tested statistically by pared t-test considering significant level of p-value <0.05.

Table 1. Details of the field arrangement for non-coplanar IMRT

Beam	Gantry Angle	Collimator Angle	Couch Angle
1	10	45	0
2	60	45	0
3	130	45	0
4	170	45	0
5	220	45	0
6	270	45	0
7	320	45	0
8	290	0	90
9	330	0	90

Results: Median PTV30 and PTV39 was 1390 (range: 1110-1810) and 18.3 (range: 2.9-45.6) cc. Radiation doses to both eyes were significantly higher in coplanar VMAT technique (p<0.05) (Table 2). There was no significant dose difference for both lens and targets between both techniques. Monitor unit was significantly higher in IMRT technique (median: 2076 (range: 1759-2201) vs. 617 (range: 584-695), p<0.001).

Table 2. Dose result comparisons of non-coplanar IMRT and coplanar VMAT